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Air operator in the plant of Deloro Stellite cutting off the rough casting from the mould.

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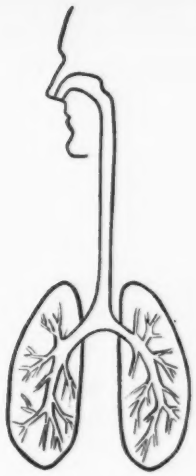

A REVIEW*

PART I. THE BIOLOGICAL SIGNIFICANCE OF DUSTS

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Meiklejohn, in his introductory remarks to a chapter in Industrial Medicine and Hygiene (edited by E.R.A. Merewether) states: "Occupational dust diseases of the lungs, the pneumoconioses, occur in mining and industrial communities throughout the world. As a result, the literature on the subject is very extensive and recognized experts have already provided many excellent general accounts of this group of diseases".

In preparing this lecture, I have drawn freely from such reviews as those by Meiklejohn, Hunter, Davies, Holt and others.

Terminology

During the nineteenth century, the dust diseases of the lungs were identified by terms descriptive of the clinical features—asthma, rot, phthisis or consumption—to each of which was prefixed the name of the associated trade, as in knife-grinders' asthma and potters' rot.

Following this initial trend, the nomenclature became more closely identified with descriptions of the morbid anatomical changes observed at autopsy in the lungs of various groups of miners. The appearances of the lungs of coal miners were called "anthracosis" and those produced by red iron oxide "siderosis". Visconti, in 1870, followed by calling the lung disease caused by the retention of silica dust "silicosis" and the same pattern has since been followed with the descriptions of "asbestosis", "talcosis", etc.

The collective term "pneumonokoniosis" applicable to the various affections of the lungs produced by the inhalation of dust-like particles, was first proposed by Zenker in 1866. It is a generic title meaning "lung" and "dust". Thus, for example anthracosis and siderosis became, as silicosis did later on, members of the group of pneumonokonioses.

The original generic term has however proved awkward and was soon after its introduction reduced to pneumokoniosis and later the spelling was changed still further to pneumoconiosis. For some years, therefore, all the various forms were used until, in order to preserve uniformity, the spelling pneumoconiosis was recommended and adopted at the International Conference of Experts on Pneumoconiosis held at Sydney in 1950.

It is generally held today that the term refers to an affection of the lungs, of occupational origin, caused by the inhalation into, and retention within the lungs of air-borne dust in the respirable size range, which may, upon retention, cause various degrees of fibrosis and which may progress to cause overt diseases with coincident disability — the progress of the disease generally being dependent upon the duration of exposure and the type and concentration of the inhaled dust.

Historical Background

A brief review of the history of the pneumoconioses amply illustrates the evolution of our knowledge of this group of diseases: from descriptions of the horrors associated with mining during the early periods in history; through succeeding stages with the gradual recognition of the value of preventive measures such as ventilation, etc.; the development of our knowledge of the pathology of the pneumoconioses; the association of tuberculosis as a complicating factor (following the identification of the tubercule bacillus); the interest in the epidemio-

* A lecture to a group of medical students.

logy of these diseases; recognition of the varying fibrosis-producing capacity of different kinds of rock dusts, to the very rapidly growing interest in the fundamental mode of action of these various rock dusts which accompanied advances in research techniques during the present century.

The history of the pneumoconioses is very ancient and has often been a subject for interesting conjecture as to the first occurrence of lung dust disease. Hunter, in his "The Diseases of Occupations", states that it probably existed in the paleolithic period because prehistoric man manufactured stone or flint instruments extensively. As far as the recorded evidence is concerned, it is interesting to note that Hippocrates (460-370 B.C.) described symptoms in metal diggers which compare well with the more modern accounts of the pneumoconioses amongst miners.

Diodorus Siculus, a Greek historian from Sicily who visited Egypt in 50 B.C., also gave a detailed account of the horrors associated with the mining of the Nubian gold mines under the Ptolemies.

Many writers contributed to our knowledge of the early history of the lung dust diseases. Lucretius, in 55 B.C., described how the "malignant breath exhaled by coal mines" affected the "features and complexions of men" and how speedily these men appeared to die. Pliny (23-79 A.D.) described the harmfulness of dust to the lungs and suggested the use of a protective mask for miners. Other contributors include Galen (131-201 A.D.) who described the occupational diseases produced by the inhalation of dust; George Agricola (1494-1555) who, in his book De Re Metallica, described the diseases which miners and refiners were prone to and in which he made a strong plea for the introduction of ventilation of mines; Paracelsus (1495-1541) who described the diseases of miners and smelters in his book Von der Bergzucht und anderen Bergkrankheiten; Van Diemensbroeck (1609-1674) who in his Anatome Corporis Humain (1672) was perhaps the first to provide a description of the morphology of a lung clogged with fine stone dust; Ramazzini (1633-1714) regarded as the father of modern occupational medicine, who in 1700 in his book De Morbis Artificum Diatriba described the special hazards involved in many occupations including the dust disease and their pulmonary lesions.

During the early 1700's it was reported how Thomas Benson of Newcastle-under-Lyme was granted patents for the wet grinding of flint in 1727 and 1732 because it was found that when the process was used dry it "proved very destructive of mankind" and that any healthy person so exposed could not "survive above two years", a state of affairs occasioned by "the dust thrust into his body by the air he breathes".

According to Hunter the starting point of the study of silicosis in modern times was a paper by Johnstone in 1796 calling attention to the high mortality among needle pointers at Redditch. Arnold Knight, a Sheffield practitioner, during the early 1800's described how fork grinders, who used dry grindstones, died between the ages of 23 and 32 years. Thackrah (1795-1832) also studied the life expectation of workers in various dusty trades and pointed out the differences in the mortality experience between that of bricklayers and lime workers, for example, who lived longer than sandstone masons who usually died before they reached the age of 40. He also focussed attention on the association of dust inhalation and tuberculosis and stressed the value of prevention.

Gregory (1831) and Marshall (1834) described the pathology of coal miners' pneumoconioses; Thomson (1837) drew attention to breathlessness, asthma, and black sputum common to coal miners; Calvert Holland (1843) described the adverse working conditions of Sheffield grinders and mentions that among 97 men about 30 were discovered by examination to be suffering from grinders' asthma and "that 35 out of 61 persons who died between the years 1825 and 1840 were under the age of 30". Peacock first established between 1860 and 1866 the existence of miners disease as an entity and distinguished it clinically from pulmonary tuberculosis; Greenhow (1860-1861) carried out the first large scale investigation into the dusty industries such as the potteries, metal trades, cutlery making, tin, copper, coal and lead mining, etc., and described the pathological changes in all the lungs of stone workers he had collected, the gritty feeling of the lungs when they were cut with a knife, etc. He was perhaps the first man to use polarized light to demonstrate fine silica particles in lung tissue.

Zenker (1860) also described in detail the anatomy of dust in lungs while Kusmaul first gave chemical proof of the siliceous nature of the dust. Visconti followed in 1870 by his description of silicosis. In 1869 Alison and Hugh Miller observed that stone drillers appeared to suffer more from the rapid onset of disease than did other miners and the conviction gradually arose that it was only in the workers with hard stone that dust diseases seriously affected health. Thus haematite miners and workers with shale and clays of various kinds were not so frequently or so early in life incapacitated from work. Moreover, fibrosis in their lungs was less nodular and more diffuse than that observed in the lungs of flint, quartz and granite

workers. These observations led to the theory that not all dusts were equally pathogenic.

In 1885 Arnold published a monograph on dust inhalation pointing out that dust particles may be found in the liver, spleen, and bone marrow as well as in the lungs. The work of Haldane (1904-1909), Wheatley (1911) and the report of a Commission on Miners Phthisis in South Africa (1912) aroused world-wide interest in the subject; the literature on which has since become prodigious.

Classification of dusts

The term "dust" as used in the above context refers to particulate matter in the solid phase but does not include organisms. It may be organic or inorganic, the physical structure of which may be present in amorphous, crystalline, fibrous, or plate form.

No simple and accurate medical classification of dusts has yet become available or proved entirely satisfactory. It may be said, however, that all dusts, organic and inorganic, in high concentrations can give rise to lung conditions which usually become manifest radiologically.

If we restrict our interest for the purpose of this discussion on classification to the harmful effects of dust on lungs, dusts may then conveniently be classified according to the nature of the lung disease provoked by them. For example: (1) *Acute pneumonitis,* edema, and/or bronchitis caused by dusts such as those of manganese, beryllium, cadmium, vanadium and their oxides. (2) *Allergic conditions* such as asthma caused by certain wood dusts, seeds, grain, wool, double salts of platinum, gum acacia, etc. (3) *Cancer*, produced by arsenic, chromates, nickel, asbestos, and radioactive emanations. (4) *Chronic bronchitis* and emphysema caused by cotton dust (byssinosis) and flax. (5) *Chronic fibrosis* produced by the common inorganic mineral dusts such as free silica (silicosis), asbestos (asbestosis), coal (coal miners' pneumoconioses), talc (talcosis or talc pneumoconioses), beryllium (beryllium granulamatosis), etc. It is with this latter group that we shall primarily concern ourselves.

Broadly speaking, these mineral dusts can be further divided into two main classes depending upon their fibrosis producing propensities: (a) inert or non-proliferative dusts and (b) active or proliferative dusts. It is to be noted, however, that mixtures of these two broad groups of dusts are common and that unless one or other of the chief fibrosis-producing constituents predominates to give rise to one of the typical pneumoconioses, modification of the type of fibrosis is likely to occur. It has also been well documented that infections, especially tuberculosis, may alter significantly the type of reaction produced in the lungs.

Before considering the biological or pathological effects in further detail, it would be desirable to review briefly some aspects of the anatomy and physiology of the respiratory system as well as the physical factors involved in the deposition and retention of dust within the lungs.

Anatomical and physiological considerations

From a physiological or functional point of view, the respiratory system can be divided into two distinct entities. First, that part which is referred to as the anatomical dead space or conducting system consisting of the nose and mouth, the throat, larynx, trachea, bronchi, and through successive branchings of decreasing size, the fine bronchioles. In this area no gaseous exchange takes place. The conducting system is lined with ciliated epithelium, the whip-like processes of which keep the bronchial mucous, secreted by numerous tiny mucous glands, moving constantly in an upward and outward direction. The muscular walls of this respiratory tree can contract and thus constrict the air passages by reflex action when particulates and/or other irritants come into contact with them.

The second part of the respiratory system is the physiologically active part or deep lung, consisting of the terminal air passages leading into the final divisions of the pulmonary tree, namely, the estimated fifty million or so tiny air sacs or alveoli.

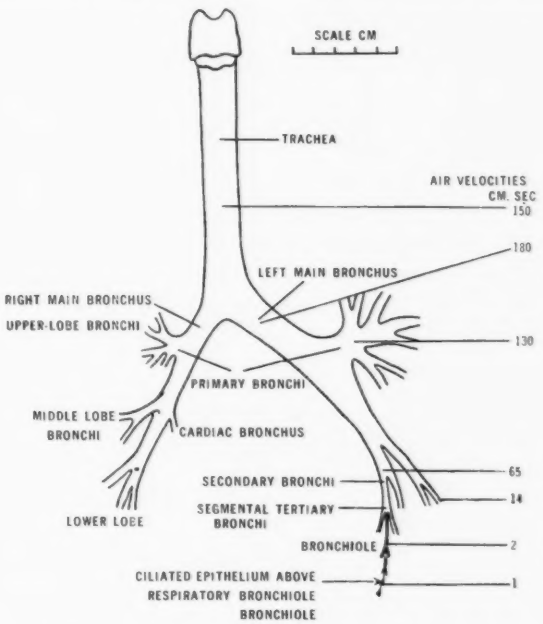


Fig. 1
Scale diagram of respiratory channels of human lung.
Reproduced from the British Journal of Industrial Medicine, 1949, vol. 6, p. 245.

It is, of course, in this area where the single layer of cells, which make up the alveolar sacs, comes into intimate contact with the ramifications of the pulmonary circulation, and that the transfer of oxygen from the air into the blood stream takes place and carbon dioxide is liberated into the exhaled air.

To provide for this gaseous exchange, air in the lungs is continually being shifted by the process of breathing. Under normal resting conditions the volume of air moved in this way amounts to approximately 500 cubic centimenters per breath of which 150 cubic centimeters, or 25 to 30% is occupied by the anatomical dead space. The normal healthy lung, however, has tremendous reserves and very much larger volumes of air can be respired when the need arises. Thus during muscular exercise when more oxygen is required by the body, more air is inhaled by an increase in the rate and depth of respiration. This, of course, increases the volume of air exchanged between the exterior and the deep lung and provides the conditions for a greater number of airborne particles to reach the deeper portions of the lungs where they may be deposited. Similarly, the higher the resting lung volume (functional residual capacity, dependent upon the size of the lungs) the more air is required to keep the air in the alveoli fresh.

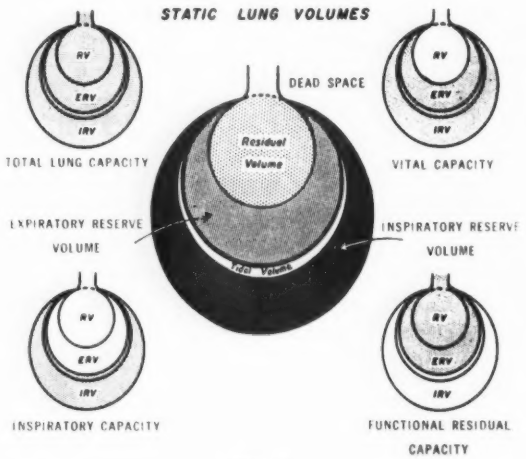


Fig. 2

Reprinted from "The Lung" by Comroe, Forster, Dubois, Briscoe, Carlsen by courtesy of the Year Book Publishers.

Normal oxygenation of the blood is further dependent upon the even distribution of ventilated air to all parts of the lung (absence of diseased areas) and on the rate of transfer of oxygen and carbon dioxide across the alveolar walls — the diffusing capacity of the lungs. The factors that influence diffusing capacity include: the distance for diffusion, which may be increased for instance by the presence of edema fluid lining the alveolar walls; and the characteristics of the tissue through which diffusion takes place such as the absence of fibrosis in the wall of the alveolus or the wall of the pumonary capillary. Whether the diffusing capacity itself may, in part, be determined by heredity is a matter for conjecture. If true, this further supports the observation that individuals do fundamentally differ in their breathing characteristics, particularly under conditions of heavy work and that in this way some may be more prone to dust injury than others because of the possible effects on deposition and retention of particles these differences may have.

Under normal conditions of increased muscular exertion or work and in order to supply the demand of the tissues for more oxygen, an additional load is placed on the heart, a load which the healthy heart is quite capable of carrying. However any derangement in the mechanism by which oxygen is supplied to the blood would also eventually have a deleterious effect on the heart if such interference becomes severe, prolonged or permanent.

To remain efficient, the lungs must be protected from hazards in the environment including dusts. Nature has provided man with reasonably adequate protection against the number of particles suspended in the non-industrial atmosphere, or what we usually refer to as clean air. Healthy lungs, in other words, can deal with a certain quantity of dust without being damaged. The defence mechanisms against such onslaught by particulates are briefly (a) the *vibrissae* of the nose (nasal hair) which act as a partial filter for the larger particles; (b) the *mucous secretions* of the nose and upper respiratory passages in which a large proportion of the inhaled particles are trapped and then expelled by (c) the wave or whip-like action of the *cilia* of the nasal and bronchial epithelium. (d) Below the respiratory bronchioles where there are no cilia, *free moving phagocytes,* or dust cells as they are sometimes called, come into play. These cells are mobilized in vast hordes when required in an attempt to cope with high concentrations of deposited dust. They engulf the particles and take them upwards to the area of ciliary action.

Particles which have been taken up to the larger bronchi and trachea are either swallowed or expectorated. Movement upward is assisted by the elastic recoil of normal lung tissue and sometimes more forcibly as a result of coughing or sneezing. In the healthy individual the mucous secretion of the lining membrane of the air passages is of a certain optimum consistency facilitating ciliary action and keeping the mucous flow upwards at a constant rate.

A small percentage of dust particles, however, are carried by phagocytes through the alveolar walls into the tissue spaces where they become entangled and either remain, or are taken along the tiny channels or lymph vessels to the lymph glands situated near the heart and larger blood vessels. It has also been suggested that particles might penetrate the alveolar walls without the assistance of phagocytes, but whatever the mechanism of traversing this area, the fact remains that dust does get into the lung tissue where cellular damage and collagen deposition is liable to take place.

Since the potential hazard arising from the inhalation of dust depends, in the case of pneumoconioses, on deposition and retention of dust particles, it is of importance to know more about the physical and other factors which may affect these processes.

Deposition of particles

The factors involved in deposition include size, density, and concentration of particles; postural and anatomical defects affecting the air passages; and the velocity of air flow into the lungs including the rate and depth of breathing.

Particle size is decisive in governing the region of initial deposition in the respiratory tract. Nasal filtering efficiency is practically one hundred per cent for particles larger than 5 μ in size. This dust filtering efficiency of the nose, however, decreases systematically with a decrease in the size of the inhaled particle, reaching zero for particles of approximately 1 μ or less. Particles in the 5 μ size range which do penetrate the nose are not likely to reach farther than the secondary bronchi, with deposition occurring particularly at the angles between bifurcations of the trachea and bronchi.

Considering particles below 5 μ in size, we find that the smaller the particles the deeper they penetrate into the lung before they are deposited to any great extent. Maximal deposition of particles in the size range 0.8-1.6 μ in diameter, for example, has been observed experimentally to occur in the fine bronchioles. Still smaller particles reach the deep alveolar sacs, where they are deposited in percentages approaching approximately 90 per cent of those actually reaching this area of the lung. In this connection, Dautrebande and co-workers have produced experimental evidence to show that this high percentage of dust deposited in the alveolar sacs is not affected by the gross number of particles in this size range present in the inspired air. In their experiments, dust concentrations varied between 15,000 to 400,000 per cubic centimeter. They also found that the maximum size of particles which reached the alveolar sacs was 1 μ in size and, further, that deposition of 0.5 μ sized particles was negligible before they reached the deep lung area.

When the overall or total deposition of particles from inhaled air is viewed in terms of nasal breathing (as opposed to mouth breathing), it will be seen that, percentage wise, deposition is essentially complete for particles of 5 μ in diameter. Deposition then diminishes, with a decrease in particle size, to reach a minimum percentage deposition at a size range between 0.1 and 0.4 μ. There is, however, evidence to indicate that, for particles smaller than 0.1 μ, deposition increases again.

Dust deposition in the respiratory tract can be thought of as a process occurring within a small compartment of air with the same physical forces in control that are involved in the dust deposition from the environmental air outside of the body. The forces of interest are of three general types (a) *inertial impaction* by which the larger particles are separated from inspired air and deposited in the nose and larger air passages, areas in which the air velocity is relatively high; (b) *sedimentation* of particles in the deeper portion of the lung where the passages are minute and the air velocity considerably reduced; and (c) *Brownian* which causes particulates suspended in relatively calm air to diffuse towards the alveolar surface on which they precipitate. Brownian motion is an appreciable factor for particles below 0.3 micron in size.

Other factors which may be of some importance to the process of deposition include: *coagulation* or aggregation of particles, certain of the effects associated with *thermal gradients*, which may occur within the respiratory tree; and also the various *electrical charges* which may be carried by and on particles. It is not yet clear what role electrical charges play in deposition of small particles. It is known, however, that maximum deposition of artificially produced unipolarly charged particles, i.e., electrically charged, occurs in the size range 0.01 to 0.02 microns, or in the electron microscopic size range. To what extent these ions, as electrically charged particles are called, are present in mine air, for example, is as yet undetermined. They are, however, receiving increasing attention from the biological point of view. It is said that negative ions produce relief in certain cases from hay fever and asthma while positive ions appear to cause stopped up noses, dryness of the mucous membranes, and headaches. Further, it has been demonstrated in the fresh rabbit trachea that the pulmonary clearing mechanism is directly affected by ionization of the air. The rate of the *movement*

of the ciliae as well as the mucous flow, were significantly reduced experimentally by positive ionization and the reverse effects were noted with negative ionization. A lack of these negative ions may, presumably, prevent this increase in physiological activity when it is needed most as, for example, under underground mining conditions.

While submicron particles may be too small to have any real inherent pneumoconiosis-producing propensities they appear nevertheless to have considerable biological significance. Further, they occur and are relatively stable in the atmosphere, have a relatively large surface area in relation to their weight, and are able to penetrate deep into the lung and are retained longer. They are also of special importance as condensation nuclei and carriers of radioactive materials and other toxic substances.

In addition to size of the particle as an important factor in the process of deposition, it is obvious that the *number*, or concentration, of respirable particles (below 5 μ) in the air will very markedly affect the number of particles deposited and eventually retained in the lungs. *Density* of inhaled particles also may affect particularly the larger particles, causing them to be impacted higher up in the respiratory system. Deposition in the lungs is influenced further, as we have seen earlier, by the *volume of air inhaled* and the *period of time* particles are allowed to remain in the lungs during inspiration. Hence slower, as well as deeper, breathing will result in an increased deposition of dust by allowing more time for particles to be deposited. Similarly, when both the respiratory rate and depth of breathing increase, as during heavy exercise, a greater dust deposition takes place.

Mouth breathing, without the aid of the filtering action of the nose, will also result in an increased deposition of dust particles, especially the larger ones. Other factors, such as the position of the body of an individual, i.e., whether in the supine or erect position, do not, apparently, alter the dust deposition characteristics significantly. A point of interest, however, is the fact that *breathing characteristics* do differ among individuals the implication being that certain individuals may be more vulnerable from the point of view of dust deposition and even dust injury.

Other factors which may influence the clearance mechanism include the action of various *toxic gases*. These may produce changes in the small air passages which may ultimately interfere with dust clearance as has been shown with exposure to sulphur dioxide and certain synthetic smogs. As far as mine gases are concerned, experiments at the Banting Institute in Toronto have shown, long ago, that they adversely affect lung clearance.

Retention of Particles

As used in the above context, deposition referred to the immediate retention of particles. True, prolonged or indefinite retention, on the other hand, is dependent on a different set of factors: the efficiency of the normal dust clearance mechanisms (ciliary action, phagocytosis, etc.); the penetration of alveolar walls, solubility and wettability, and the chemical properties of the particulates. In man, all these factors have not yet been clearly elucidated.

The removal of particulates from the alveolar portions of the lung is a slow process. The dominant mechanism appears to be the engulfment of particles by phagocytes which wander upwards towards the small bronchioles where the dust becomes subject to the action of the cilia. Material may, in this way, be eliminated from the bronchial tree for as long as eight months after termination of exposure. Animal experiments have suggested that larger particles may be removed at a faster rate than smaller ones. Stokinger has found that particles of 2.6 μ were removed in less than half the time it took for the same percentage of particles in the size range 0.45 μ to be removed. There appears to be no difference in the rate of removal from the alveolar sacs to the air passages of particles of differing fibrosis-producing potential.

The limits of particle size outside which phagocytosis is ineffective are unknown. It has been observed, however, that the rate of phagocytosis for any given material is proportional to the probability of a collision between the particle and a cell, the process thereby favouring the larger particles. There is also some degree of selection and rejection as shown by experiments in which rat phagocytes ingested carbon about four times as readily as silica. On the other hand, after penetration of the alveolar wall, carbon-bearing cells migrated more slowly into the lymphatics than did those bearing silica. Evidence thus suggests that in the lymph vessels the smaller and more fibrogenic dust particles are removed at a faster rate towards the lymph nodes.

From human lung studies in South Africa, the United Kingdom, and America, it has been learned that the vast majority of retained particles are in the region of 1 μ or less. Bedford and Warner, for example, made a detailed size distribution count of dust particles found in specimens of lung tissue from a shot firer who had died after many years

of work in an anthracite mine. Of all the particles counted, only 0.3-0.4 per cent of particles were larger than 5 μ in diameter and an occasional coal particle as large as 8 μ was found. Of non-coal particles 86-87 per cent were below 0.8 μ.

Although normally only a very small percentage by weight of inhaled dust particles is retained by the lungs, increased retention will follow exposure to excessive and prolonged concentrations of dust. Under these conditions the normal defences against dust retention fail, and it is essentially this failure which is the underlying factor in the development of the pneumoconioses. In part, it is also dependent on the inherent toxicity of retained dust.

Pathological effects

The pathological effects of retained particulates are dependent on a number of interrelated factors and may be grouped into two separate categories. One group pertains to the physical and chemical characteristics of the particle per se and the other relates to the exposed individual, the duration and severity of his exposure, his age, sex, and general health status.

Physical and chemical characteristics determine largely the site of action, not only in the respiratory tree but also general body or distant organ effects as in the case of soluble, absorbable dusts e.g. lead dusts, etc., as well as local effects which may follow the more gradually absorbed or insoluble dusts.

Droplets of water soluble dusts may act as chemical irritants and may well produce different consequences depending on whether the irritant action occurs in the upper respiratory tract or in the deeper lungs — a function of their size and deposition and other physical characteristics.

The more slowly dissolved and insoluble particles include, as we have seen in our classification of dusts, the inorganic mineral dusts which are responsible for chronic fibrosis of the lungs. These dusts fall into the two broadly classified groups, (a) inert or non-proliferative dusts and (b) active or proliferative dusts.

A. INERT OR NON-PROLIFERATIVE DUST DISEASES:

Benign Pneumoconiosis

The term *benign pneumoconiosis* refers to a non-disabling condition of the lungs produced by dusts which seem to be inert when inhaled. These dusts include coal dust and compounds of certain metals, among them calcium, iron, tin, and barium. Inhaled particles which are retained in the lung tissue are capable of lying there for years without inducing development of fibrous tissue or pulmonary disability, but because they are relatively opaque to X-rays, they may produce changes in the X-ray film which then must be distinguished from those of silicosis. Dusts of limestone, marble, lime, and cement, for example, produce no symptoms of real disability. Similarly, the retention of haematite dust (siderosis) is essentially not disabling provided that the free silica content is not appreciable and that exposure to excessive concentrations for long periods of time did not take place.

Pure coal dust is essentially an inert dust. However, excessive concentrations, prolonged exposure, and the onset of tuberculosis as a complicating factor may convert cases of simple pneumoconiosis into cases with progressive massive fibrosis as will be seen later.

B. ACTIVE OR PROLIFERATIVE DUST DISEASES:

Silica and Silicosis

It is well known today that, as Collis suggested in 1915, the disease silicosis is caused by the inhalation of free silica (crystalline free silica). Pure quartz, or silica, consists of only one chemical compound with the formula SiO_2. Most rock, like granite, contains, in addition to quartz, varying proportions of several other minerals such as feldspar and mica. Both these minerals contain silica although it is present in the form of silicates rather than as SiO_2. Quartz and other forms of the chemical compound SiO_2 are spoken of as free silica whereas the oxide of silicon contained in feldspar and other silicates form chemically combined silica.

Free silica occurs in nature as quartz or opal. Common varieties include amethyst chalcedony, agate, onyx, flint, jasper, crystobalite, and tripolite. Free silica is the major constituent of sand, sandstone, and granite. Exposure to silica occurs, and has occurred, in hard rock mining, in foundries, in the manufacture of porcelain and pottery, in the spraying of vitreous enamels, in sand blasting, in granite cutting, in tombstone making, in grinding and polishing operations where natural abrasive wheels are used and in many other occupations.

From evidence thus far collected it seems likely that silica particles in the size range 1-2 μ in diameter are the most active in the production of nodular fibrosis. Once these small particles have traversed the alveolar wall, either directly or

through phagocytosis they may pass to areas of lymphoid tissue in the region of the respiratory bronchioles or perivascular tissues, pleura or the hilar chain lymph nodes. In all these areas fibrosis may occur.

Typically, silicotic nodules consist of whorls of dense avascular, fibrous or collagen tissue surrounded at the periphery by a layer, or an accumulation, of pigmented dust cells. Each nodule is generally from 2 to 5 millimeters in diameter in well developed cases and several may coalesce to form a large composite nodule or, with advancing disease, may be united in a massive fibrosis.

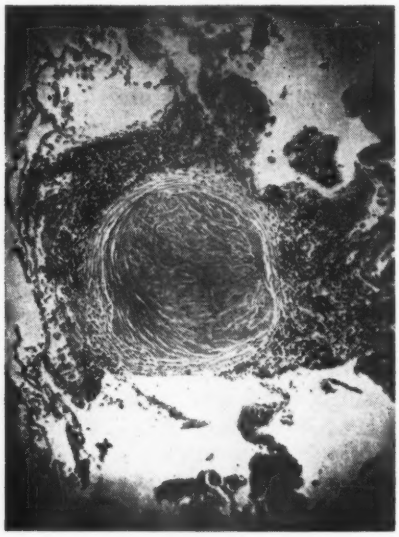


Fig. 3

Photomicrograph. Fully formed single small "non-infective" silicotic nodule. Note that the simple silicotic islet consists of a central area, composed of well-formed dense fibrous tissue with scanty cells and little pigment; most of the pigment is lying free. At the periphery of the islet the arrangement is that of concentric laminae and the tissue is fibro-cellular. The islet is surrounded by an accumulation of pigmented "dust cells".

(By courtesy of the Editor the Proceedings of the Transvaal Mine Medical Officers' Association)

Reproduced from "Industrial Medicine and Hygiene" by E. R. A. Merewether, vol 3, p. 16.

In long standing cases, individual nodules may be thrown into sharp relief by emphysema of the surrounding lung. Conglomerate lesions or massive fibrosis usually occur in association with tuberculous infection. It is well known that silicosis predisposes to the development of complicating tuberculous infection. Similarly, it has been found that in cases with chronic or long standing tuberculosis, dust particles tend to accumulate in or near these diseased areas and enhance the primary disease.

All forms of crystalline free silica, when inhaled in excessive concentrations, produce progressive fibrosis with continued exposure, and for a limited period of time, following the cessation of exposure. Regression is not a well described pattern, but it is possible that it occurs with certain silica dust mixtures to some extent, after cessation of exposure of some years duration.

The forms in which crystalline free silica occur include quartz which is the stable form at temperatures below 870°; tridymite, the stable form between 870° and 1470° and crystobalite the form between 1470° and its melting point of 1700°. Tridymite is the most fibrogenic, followed by crystobalite and quartz in that order.

It was once held that amorphous forms of silica were not responsible for severe silicotic lesions. Cases of pneumoconiosis had, however, occurred in which the fibrosis appeared to be more diffuse, instead of nodular. Flint is predominantly an amorphous silica capable of producing a severe degree of fibrosis. Fused silica, on the other hand, has been relatively free from serious biological effects in man.

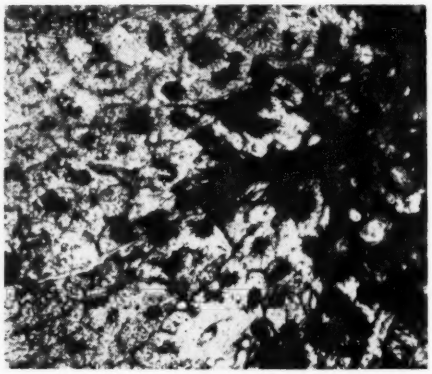


Fig. 4

Silicosis. Upper part of the lung of a South African gold miner showing discrete and confluent silicotic nodulation (magnification × 1⅛)

(By courtesy of Prof. J. Gough.)

Reproduced from "Industrial Medicine and Hygiene" by E. R. A. Merewether, vol 3, p. 18.

Many theories have been advanced to account for the fibrogenetic effect of crystalline free silica. Some of these such as the potential harmfulness of the sharp edges of silica crystals (mechanical theory) have long since been discarded. So too was the theory which ascribed fibrogenicity to inherent radioactivity of particles. At one time also, it was thought that the electrical charges associated with asymmetrical crystals might be the cause of the

fibrosis (piezo-electric theory). Although there is possibly still much to be learned about the role of these electrical charges, the theory itself has been largely disproved by the fact that tridymite, which is non-piezo-electric, is several times more fibrogenic than quartz. A suggestion that freshly fractured rock dust may have certain inherent properties which may make it more harmful than aged dust, has also at one time received and is still receiving consideration.

Following the work of Gye and Purdy (1922) and Kettle (1932) the chemical or solubility theory came much to the fore. This theory suggested that the particles of dust which get into the lungs are pathogenic, not because they produced microscopic trauma but because something of a toxic nature dissolves from their surfaces. This substance was thought to be silicic acid.

Some anomalies in the application of this theory were, however, soon discovered. King, for example, pointed out that while cement contained free silica, exposure to excessive concentrations did not give rise to classical silicosis. Holt and others then advanced a modification of this theory by suggesting that it was necessary for ortho-silicic acid to be formed at the surface of the particle at a low pH. When the silicate ion thus formed is neutralized by the tissues to the pH of plasma it passes through a pH in the region of 5.5 to 6 (a region of pH in which polymerization is most rapid) to form polymerized or polysilicic acid. It was thought that it was this polysilicic acid which was the immediate causative agent in the production of the fibrotic nodule. Cement dust also dissolves to produce a high concentration of silicic acid but at an alkaline pH, so that in diffusing away from the dust particle the silicate ion is brought to the pH of plasma without passing through the pH range in which rapid polymerization occurs.

Another theory followed the demonstration by Fallon that an increase in the lipid content of lungs of experimental animals occurred after the intratracheal injection of a suspension of silica particles. This suggested that when silica containing cells die, phospholipids are released which may cause local fibrosis in the same way that the phospholipids contained in the waxy capsule of the tubercle bacillus cause a local granuloma (lipid theory).

In more recent work the dust cell and the role of the intra-cellular particle received renewed and increasing attention. It has been suggested that engulfed particles caused the destruction of dust containing cells with the release of certain substances capable of acting antigenically (immunity theory). The response to such antigens is said to be characterized by the appearance of plasma cells and fibroblasts and later the deposition of collagen.

Despite the very many different theories and modifications advanced in an attempt to explain the action of silica, no one theory has as yet explained all the factors related to the production of the silicotic nodule conclusively.

Pneumoconiosis Associated With Other Siliceous Dusts — The occurrence of pneumoconiosis following exposure to dusts of crystalline and amorphorous silicates is, with the exception of asbestos dust, less severe than that produced by quartz dust (free silica).

Silicates represent an enormous number of siliceous dusts, (including the various clays) in which the SiO_2 groups are again in chemical combination, possibly in some cases with fibrosis-inhibiting groups. Although many cases of pneumoconiosis have been reported among men who work with them (e.g. kaolin, fuller's earth, etc.), the circumstances were too complex and varied to permit easy classification. The difficulties are that rocks and clays are mixtures which frequently contain free silica along with the silicates and that tuberculosis often complicates the clinical picture especially in cases resulting from long exposure to dust.

Several accounts of pneumoconiosis as a result of exposure to feldspars or *non-fibrous crystalline silicates* have come to hand. The severity of the pneumoconiosis so produced was generally less than that of free silica; the lesions were more widely disseminated with less increase in fibrous tissue. Again many of these cases were complicated by the presence of free silica.

A number of cases of pneumoconiosis, as a result of exposure to a mixture of pure basic feldspars, namely nephalite, albite, microcline (nephaline syenite) were described by Dr. A. R. Riddell of the Ontario Industrial Hygiene Division. In these cases the lungs were overwhelmed by a dust which contained no free silica, and which apparently did not produce a significant degree of fibrosis but which caused alveolar and also some interstitial clogging. In the early stages of the condition, only slight disability was evident, but with progression, these cases became complicated by the addition of a low grade type of infection. This infective process produced areas of pneumonitis which, unlike tuberculous infection, cleared up or shifted to involve other parts of the lung. With the onset of this super-imposed low grade infection, breathlessness often became pronounced. The microscopical examination of the lungs in these cases revealed slight diffuse interstitial non-nodular

fibrosis, some thickening of the alveolar walls, with a little focal emphysema.

Of the *fibrous crystalline silicates,* asbestos is by far the most important. Asbestos shares with free silica the capacity for producing, although somewhat less rapidly, a severe degree of fibrosis of the lungs when asbestos dust is inhaled in high concentrations.

Asbestosis is caused by the inhalation of dust which arises from the various types of asbestos. These substances are fibrous silicates and are known as chrystile, crocidolite, and amosite. The characteristics of these depend on the type of fibre and on the particular silicate of which the fibre is made, as well as the surrounding rock. Both asbestos fibres and the dust are inhaled.

The lesions produced are characterized, not by nodules of fibrous tissue as in silicosis, but by a more diffuse type of fibrosis which affects primarily the lower portions of the lungs. There is a fine network of fibrosis throughout these areas, particularly around the bronchioles and alveolar ducts. Unlike silicosis, it does not appear to predispose to tuberculosis although respiratory illness may gravely affect the prognosis of the individual and may even be of critical etiological significance. Further, asbestosis does not appear to progress at the same rate after cessation of exposure.

The causative factors in the production of fibrosis have not yet been clearly defined. Some possibly related and important factors include:

(a) The length of the inhaled asbestos fibre. It has been suggested that fibres below 10 μ in length cause very little fibrosis. (While the length of fibres found in the lungs of human cases of asbestosis varies between less than 5 μ to over 100 μ, animal experiments have suggested that only asbestos fibres which are more than 20 μ and less than 50 μ long cause fibrosis. Those of less than 3 μ in size showed little reaction.)

(b) The mobility of the lung allowing these inhaled fibres to cause repeated injury (asbestos fibres have not been found to produce experimental evidence of fibrosis in such non-moving sites as liver or subcutaneous tissues);

(c) A specific chemical action. The chemical theory of asbestosis regards the disease as a special form of silicosis. It has been suggested that the lung damage may be due to (presumably) silicic acid which is liberated when the asbestosis bodies disintegrate.

A characteristic feature of the lung sections from cases of asbestosis and the sputum of individuals exposed to asbestos fibres is the presence of large numbers of peculiarly shaped structures referred to as "asbestosis bodies". These bodies are dumb-bell shaped and are formed very rapidly (sometimes within two months) after exposure commences, probably as a result of colloidal reaction with blood proteins in which iron plays an important part.

Statistics have been published which suggest that the incidence of cancer of the lung is higher among workers with asbestosis than among the general population. While most investigators believe that a relationship is probable, there are some who do not. Experiments with animals have also shown inconclusive results. It is of interest however that Doll in his investigation stated: "From the data it can be concluded that lung cancer was a specific industrial hazard of certain asbestos workers and that the average risk among men employed for 20 years or more has been of the order of 10 times that experienced by the general population." He pointed out also that the workers examined had worked in the industry before the pathogenic nature of the dust was recognized and before the introduction of regulations which controlled the conditions in asbestos factories.

Talc has a tendency towards being a fibrous silicate. While both the fibrous and the non-fibrous varieties can produce mild pulmonary fibrosis, it is the fibrous, or tremolite variety, which is the more fibrogenic. This latter variety produces a diffuse fibrosis not unlike that of asbestosis.

Talc bodies, resembling asbestos bodies, have also been found in the lungs and sputum of individuals exposed to talc dust and in cases of talc pneumoconiosis (talcosis).

Coal Miner's Pneumoconiosis — Coal miners' pneumoconiosis may be classified into two different types: simple pneumoconiosis of coal miners and progressive massive fibrosis of coal miners. Nodular silicotic lesions may also be found in the lungs of drifters and roof and pavement brushers who, during the course of their work, have been exposed to free-silica dust.

Simple coal miners' pneumoconiosis is, as a rule, accompanied by very little fibrosis and the pathological picture presents the features of clogging of the alveoli and lung tissues. Dust collects around small vessels and bronchioles and after prolonged and excessive exposure may give rise to only a little diffuse interstitial fibrosis. A late sequel to this kind of pneumoconiosis is the development of fine emphysematous changes which follow the gradual obstruction of the terminal bronchioles. It is this emphysema which gives rise to the disability experienced by miners with uncomplicated pneumoconiosis.

The view has been held by some that the presence of free silica is essential for these changes to occur. Pneumoconiosis of coal miners is, however, found amongst coal miners as well as coal handlers such as those employed as coal trimmers who have never worked in a quartz seam. Further, coal, at most, contains only approximately 5%

free silica. That these changes could follow simple coal dust exposure, in other words, that they are a result of coal dust retention, per se, has recently become more generally accepted.

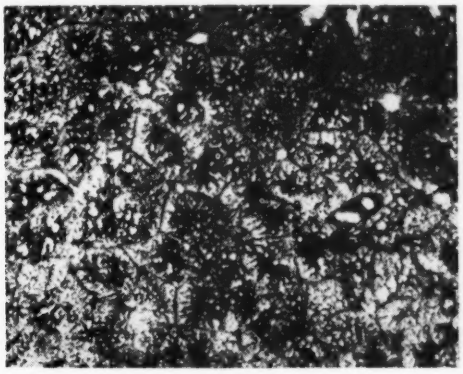


Fig. 5
Simple pneumoconiosis with focal emphysema in a coal-tipper (magnification × 1⅛)
(By courtesy of Prof. J. Gough.)
Reproduced from "Industrial Medicine and Hygiene" by E. R. A. Merewether, vol 3, p. 21.

Another factor which has received consideration in the etiology of this condition is the rank of coal, since it became known that a higher incidence of pneumoconiosis occurred amongst anthracite workers than those exposed in bituminous coal mines.

Progressive massive fibrosis of coal miners is, as the name implies, a progressively disabling disease. It may follow severe cases of simple pneumoconiosis of coal miners with coalescence of foci of retained coal dust and the production of massive areas of fibrosis. In the vast majority of cases, however, if not all, some form of tuberculous infection is associated with this change.

Fig. 6
Large lung section. Massive fibrosis; complicated pneumoconiosis. Coalminer in South Wales. — 48 years.
(By courtesy of Prof. J. Gough.)
Reproduced from "Industrial Medicine and Hygiene" by E. R. A. Merewether, vol. 3, p. 23.

Graphite dust, like coal dust, is perhaps essentially non-fibrogenic. In nature, however, it occurs always in association with free silica and the occasional cases of disability reported amongst graphite workers may well, in part, have been due to the complicating action of a higher percentage of free silica in the respired dust.

Other Fibrogenic Dusts —A variety of other dusts, primarily metallic dusts, may — in addition to acute effects such as chemical pneumonitis — also give rise to chronic or permanent lung fibrosis with disability. These dusts include Beryllium, Vanadium, Aluminum, etc.

Both acute and chronic forms of berylliosis have been described as the result of exposure to beryllium metal, beryllium oxide and other compounds of beryllium. Exposure to the dust from beryllium ore, or beryll, on the other hand, is generally considered to be free from serious biological effects.

The acute disease is a chemical pneumonitis. It starts as a cough followed by dyspnoea and death may occur within two weeks.

Chronic berylliosis may in the occasional instance develop as long as six years after last exposure to beryllium dust. The symptoms usually start with vague ill health and it may be weeks or months before abnormal signs appear in the lungs. There is extreme breathlessness which is usually out of all proportion to the degree of radiological evidence of the disease.

The pathological findings in chronic berylliosis resemble closely those found in sarcoidosis. The lungs are grossly emphysematous with universally scattered fine, gray, granulomatous, miliary nodules and diffuse interstitial fibrosis. The granulomata are formed within the alveolar spaces by organization of exudate. They have a fibriloid centre with peripheral fibrosis.

Radiologically the lungs of a person with chronic berylliosis show a diffuse, finely granular appearance which is homogeneously distributed. Later, as the disease progresses, fine nodulation is superimposed on this picture.

Individual susceptibility may play an important part in the disease. Duration of exposure per se may thus become of relatively minor importance.

Vanadium is also more active as a chemical poison, although chronic dust effects (reticulation) as observed radiologically, have been described in a number of workers exposed to it.

Aluminosis — During the Second World War, powdered metallic aluminum was used extensively in the manufacture of explosives, incendiary mixtures and paints. The powder was made by two processes: either it was blown, when the particles were covered by a thin film of aluminum oxide, or it was stamped when they were covered with a thin film of stearine.

In German factories where aluminum powder was made by the stamp process, many workers were affected by a severe pneumoconiosis (aluminosis). Histological examination of sections of the lungs of a patient who died revealed coarse interstitial (non-nodular) collagenous fibres which enclosed dust-laden phagocytes. The illness developed rapidly and spontaneous pneumothorax was described in several workers.

Various reasons for this occurrence have been offered such as: the omission of lubricants in the stamping process; the effect of an "ersatz" vaseline added in place of the usual stearine; or just simply because of the increase in the amount of dust in the atmosphere in consequence of wartime conditions. Theoretical approaches to the etiology of this condition included the suggestion that a colloidal aluminum hydroxide complex is formed (because of the solubility of aluminum powder in saline solutions) and that this is capable of reacting with proteins as silicic acid does.

In 1947 Shaver and Riddell reported on an occurrence in Canada of pneumoconiosis in bauxite smelters (Shaver's disease). In this process bauxite ore is fused to form corundum — a kind of artificial emery. Workers exposed to the dense white fumes produced during this process developed the disease which was characterized clinically by the occurrence of spontaneous pneumothorax and severe disability.

Histologically, interstitial fibrosis with involvement of the interalveolar septa developed. With subsequent shrinkage of the fibrous tissue, large emphysematous bullae were formed, generally at the periphery of the lung fields and in the upper zones. At the same time this shrinkage of fibrous tissue also seemed to pull the mediastinum upwards followed later by basal emphysema and distortion of the diaphragm, as seen radiologically. It is interesting to note that in these cases no fibrosis of the tracheobronchial lymphodes were observed. Once again, as in Germany, the stresses of wartime production can be clearly discerned in the pattern of this occurrence.

In view of the fact that the fumes, in addition to alumina (50%), also contained amorphous silica (32.3%) the etiology of this particular fibrosis was held uncertain. That it is another example of aluminosis is, however, now generally accepted. No particular association between Shaver's disease and tuberculosis was observed.

Another incidence was reported by Hagen who examined 25 workers with pneumoconiosis who were employed at smelting ovens where pure calcined alumina was processed to produce corundum. This corundum dust contained 99.3% Al_2O_3 so that there could be little doubt that the aluminum oxide itself was the pathologic agent.

Recently the occurrence of a further number of cases of pneumoconiosis as a result of exposure to finely divided aluminum dust has been described in Great Britain. Clinically, radiologically, and histologically, these cases were similar to those in Germany and Canada. The condition of aluminum lung or aluminosis which follows exposure to high concentrations of aluminum dust has thus become well established. As we shall see later aluminum dust in low concentrations is also being used as a prophylactic agent against the harmful effects of free silica. The essential differences between the two kinds of exposures appear to be the concentration (or dose) and the rate of exposure. Aluminosis is therefore not necessarily an argument against aluminum therapy.

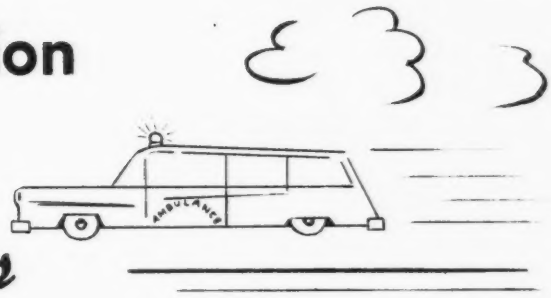
Fluoride dusts have been known to cause pulmonary fibrosis. Roholm described mild non-nodular fibrosis of the lungs in workers exposed to cryolite (sodium aluminum fluoride), which did not appear to progress after cessation of exposure. There was, on the contrary, some evidence that the fibrosis diminished.

Pneumoconiosis has also been described among fluorspar (calcium fluoride) miners.

Fluorspar miners are, however, also exposed to varying concentrations of free silica containing dust. Furthermore, the severity of the pneumoconiosis among fluorspar miners, as assessed clinically and radiologically, appears to be directly proportional to the concentration of free silica present in the dust. A relatively minor degree of nodular pneumoconiosis has been described amongst miners exposed to fluorspar dust combined with low concentrations but a severely disabling and progressive pneumoconiosis occurred amongst individuals exposed to fluorspar dust mixed with up to 60% free silica. The severity of the latter occurrence suggested the possible potentiating effect of mixtures of this kind. The essentially nodular fibrosis produced may indicate a modified form of silicosis.

(*Continued on page* 18)

The need for regulation of *Ambulance Services*



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An ambulance service is something which everyone expects to be on the spot at the time of need, but scant thought and attention is given to ambulance services at other times. Few people ever give a second thought to the standard of competency of ambulance services. If the public judge at all it will be on the speed at which the ambulance travels, the loudness of the siren and the brilliance of the flashing red light; some may even be impressed by the hurried and unceremonious lifting of the patient from the ground into the vehicle by white coated attendants.

In recent years a few communities in Canada have been turning their attention to the problem of operation of road ambulance services. Saskatchewan first had provincial regulations governing road ambulance services in 1946 but they were minimal and unfortunately rarely enforced. In 1957 it became evident that a survey of provincial ambulance services was needed in order to determine what standards should be enforced in Saskatchewan. This task was given to me, and I visited the majority of ambulance services which were known to be operating. Because of the absence of any system of registration it was impossible to be certain that all services which were operating were known, but as much of the information came from local sources it was probable that few were missed.

The majority of ambulance services in Saskatchewan are operated by funeral homes. To some this may seem peculiar, but one only has to go back to the pioneer days to understand how this situation arose. In these times it was probably only the undertaker who had a vehicle which would transport a lying case in reasonable comfort. Embalming processes required some knowledge of anatomy by the undertaker's staff, so it was logical that they should be the persons to give first aid when required. The fact that their work could, without serious detriment, be postponed for an hour or so was an additional reason why undertakers operated early ambulance services.

A secondary reason for funeral homes operating ambulance services, and this applies particularly when two are in competition in the same town or city, is the ability to advertise the funeral home by means of its ambulance service, it being illegal for embalmers to advertise an undertaking business in Saskatchewan. That this is still a major consideration is evident when, although neither of two funeral homes in a town are particularly enthusiastic about operating an ambulance service per se, they will not abandon this service unless it is taken over by someone who does not operate a funeral home. Although the business motive is prominent and frankly admitted, there is also a sense of service and a feeling of responsibility to the public who patronized their funeral home in the early days and enabled a successful business to be established.

In the larger cities the trend has been towards the development of what might be called professional ambulance services doing nothing but ambulance work. This divorce from the undertaking business which is able to subsidize an ambulance service has created financial problems of operation by city services and has led to the granting of subsidies by the councils of some cities.

Hospitals in two of our smaller cities operate their own ambulance services. In one, a local taxi service provides the driver as required, and in the other the hospital radiographic technicians make up the crew. There are also two municipalities who operate ambulance services, these in each case having been taken over from a privately operated service to maintain a service which otherwise would have been abandoned; and finally there are a few individuals in small communities with none

of the connections listed above who operate an ambulance service, usually taking no more than a dozen calls in a year.

Diverse as these ambulance services are in their operation, they all have one thing in common — they have real and severe financial difficulties. The reason is easy to understand when one considers the cost of vehicles and equipment, the necessity of being on 24-hour call, and the inevitable low percentage utilization. The situation can be compared with the proverbial horse eating its head off in the stable. This has resulted in difficulty in paying wages sufficient to attract and retain good and experienced attendants, this being especially a problem of the professional ambulance services.

What should or could be done about ambulance services at the provincial level? There is no doubt in the minds of physicians and others who have given this matter some thought and have seen the results of unskilled first aid attention, that some action is needed. It should not be thought that this will be resented by ambulance service operators. This situation can be likened to the politician who delights in praise, will accept violent criticism with good grace but cannot tolerate being ignored. Ambulance services have been ignored by the public, medical profession and the authorities for too long and this has had a demoralizing influence.

The existing legislation in Saskatchewan which came into force in 1958 cannot be regarded as providing the complete answer to the problem, but rather as an interim step in the direction of province-wide highly efficient ambulance services. The road ambulance regulations deal with two basic aspects — training and equipment, the latter varying slightly according to whether the service is operating from a city or otherwise. Some of the main features of the regulations and the reasoning behind them will be discussed.

Registration

All services are required to register annually with the Minister of Public Health. This enables the Department to arrange for inspection of the services in regard to sections of the regulations dealing with training and equipment. The registration information concerning the numbers of trained personnel and vehicles is surely a statistic any public health department should have for its province. It also provides a mailing list for forwarding technical information concerning supplies and equipment and the details of the advanced first aid courses held annually.

Training

The first requirement is that every ambulance must have one attendant who holds a valid St. John Ambulance Association First Aid Certificate. However, in our opinion this does not go far enough. It is possible to obtain this certificate without receiving any teaching from a member of the medical profession. Even during the examination for the certificate the candidate may meet the physician only briefly. The medical profession should and must take more responsibility for the training of these professional first aiders. There are many specialized first aid problems and techniques which the ambulance crews have to cope with but which are not dealt with in the standard first aid text books. Examples include the care of certain emergency medical cases in transit, emergency obstetrics, the use of oxygen, aspirators and resuscitators, and the extrication of persons with multiple injuries from crashed cars. The medical profession has with good reason been critical of some of the first aid care given, but it cannot continue criticising unless it shoulders some of the responsibility for ensuring a high standard of first aid care.

Our one day courses in advanced first aid which all ambulance personnel have to attend at intervals of not more than 3 years are somewhat of a compromise. A longer course would be desirable but many ambulance attendants, with problems of suitable reliefs, would be unable to stay away for longer. It was felt that under present circumstances attendance at this one day course was as much as could reasonably be expected. The medical profession in our two main cities of Regina and Saskatoon have taken an increasing interest in the courses. The pattern has been for six specialists to have a session each — a general surgeon, a neurosurgeon, an orthopaedic surgeon, an internist, an obstetrician, and an anaesthetist. No detailed syllabus has been drawn up, but at some future date in the light of experience this may be done. Apart from the value of the didactic teaching, there is the benefit of the free discussion after each session between the doctor and the ambulance attendants who usually number about one dozen. In rotation, safety and first aid equipment companies operating in Saskatchewan are invited to provide a small display of equipment and supplies for ambulances at the course. These items can be used by the physicians in demonstrating first aid procedures.

The general consensus among the ambulance operators is that the courses are of considerable value to them. For the first time they feel they are recognized as a service group by the medical

profession and the government. The courses also enable ambulance service operators and attendants to meet each other and discuss topics of common interest. One result has been the formation of the Saskatchewan Road Ambulance Association which is beginning to take an active interest in the future planning of ambulance services in the province.

Supplies

When accidents occur, and particularly highway accidents, severe and multiple injuries may have to be treated. One has only to witness the application of small dressings in such cases to realize how futile they are. The regulations therefore require ambulances to carry a good supply of large sterile dressing pads the largest being 6" x 6". If an 8" x 8" size were available commercially this size would have been included in the dressings list.

Canada's very high insurance rates for fire risks reflect the need to consider appropriate first aid treatment for the victims. Undoubtedly, the prevention of infection is the first objective and this can best be achieved by a sterile covering. Where extensive areas of the body are burned, wrapping the limb, or, if necessary, the whole patient, in a sterile bed sheet is the best treatment. The hazard of infecting the burn or scald during prolonged manipulations with smaller dressings is considerably reduced. Our ambulances are required to carry two sterile sheets for this purpose.

Equipment

The St. John Ambulance Association for some years has advocated the use of the rubber constrictive bandage instead of the tourniquet, the use of which is not infrequently accompanied by damage to vital soft tissues, particularly in unskilled hands. One of these constrictive bandages has to be carried in each ambulance.

Courtesy of the National Film Board.

Few of our ambulances are large enough to carry two ambulance stretchers. As highway accidents frequently result in at least 4 stretcher casualties, and often only one ambulance is available in thinly populated areas, they are required to carry an additional stretcher. The ordinary folding canvas stretcher with wood poles known as the Furley stretcher is the one recommended because of its low cost. Then, if a less urgent casualty has to be left at the scene, he can be placed comfortably on this Furley stretcher and, if necessary, taken to a barn or house to await the return of the ambulance. If another suitable vehicle is available, the patient can be taken in it on this stretcher. As so many highway accidents result in spine injuries, this requirement is regarded as being particularly important in preventing the mishandling which can have such serious consequences. If a casualty cannot be taken in the first ambulance load, the great temptation is always to rush him to hospital by the quickest available means without considering the possible consequences.

Another cause of spine injuries is falls at construction sites, storage tanks, and the holes which are dug in the ground for a variety of purposes. Lifting, lowering and otherwise extricating these victims presents a major threat, and it is for this reason that city-based ambulances have to carry a Haggard, Neil Robertson, or other suitable stretcher. These stretchers hold the patient firmly and rigidly, so he can be hoisted or lowered by rope or manoeuvred in passages or tunnels without risk of aggravating previous injuries.

How rarely does one see the proper method of transporting a case with a suspected fracture of the neck! The placing of two small sand bags on either side of the head when the patient is lying on the stretcher will prevent the head rolling movement so liable to occur in a moving vehicle.

The cause of early death in many cases of head injury has been recognized to be asphyxiation, not due directly to brain damage but to obstruction of the upper respiratory passage. This unnecessary loss of life can be prevented by the correct placing of a simple airway in the patient's mouth. Two of these airways are on the equipment list. Also associated with head injuries and with other types of accident and illness is the need to remove blood, mucous, cerebrospinal fluid and vomitus from the throat. The "death rattle" of the fractured skull victim need not portend a fatal outcome if the respiratory passage is kept clear. Therefore each ambulance is required to carry one

aspirator. The city-based ambulances are not required to carry a separate instrument, as an aspirator is incorporated in the resuscitator which only the city ambulances are required to carry. These will be discussed below. In the interest of economy we have been suggesting that operators make their own aspirators in the manner described by Dr. M. A. Nicholson[1]. This aspirator can be made from a car tire pump, a bottle and some tubing.

As mentioned above, city-based ambulance services have to carry a resuscitator. The type recommended is one which can be used either in the positive and negative phases or in the positive phase only. There is good evidence[2] that the double phase is more effective in resuscitation, but on the rare occasions when pulmonary oedema is present, or is liable to appear, for instance after the inhalation of an irritant gas, it is preferable to use the positive phase only to reduce the possibility of producing or aggravating this condition.

The non-city ambulance is required to have equipment for administering oxygen in lieu of a resuscitator.

Space has not been available to describe and discuss the entire range of supplies and equipment Saskatchewan ambulances carry but the ones referred to here are regarded as being some of the most important.

Ambulance services have not received the attention they have deserved from government, the public, and medical profession. If victims of accidents and illness are not to receive second class rides, measures have to be taken to improve standards of ambulance services. This implies basic regulations, a training program and in many instances some form of financial support.

References

1. Nicholson, M. A.: A Portable Suction Pump and Its Uses, Canad. Anaes. Soc. J., 2, 84-86, (Jan.) 1955.

2. Maloney, J. V. et al.: Importance of Negative Pressure Phase in Mechanical Respirators, J.A.M.A., 152:212-216, (May 16) 1953.

Copies of the Saskatchewan road ambulance regulations may be obtained by writing to: Dr. N. Williams, Director, Occupational Health Branch, Department of Public Health, Health and Welfare Building, Regina, Saskatchewan.

PNEUMOCONIOSIS — A Review

(Continued from page 14)

C. ENHANCING (POTENTIATING) AND RETARDING DUSTS

That the fibrosis-producing potential of dusts, like free silica, may be enhanced or retarded by the presence of other mineral or metallic constituents in the source material has been suggested many times. Sericite, as long ago as 1926, was held to be a potentiating agent in silicosis. Since it occurs in many rocks in association with quartz, it is not surprising that it has been found in the lungs of miners with silicosis. It is, however, thought to be a residual material only and has been found not to cause progressive fibrosis of the lungs by itself. A true potentiating effect may, however, be present in the case of fluorspar when the concentration of free silica in the inhaled dust is high.

Retarding or antidotal dusts, on the other hand, have naturally received a great deal of attention. These include particularly calcium salts and the aluminum silicates. The presence of aluminum silicate in the ore bodies of the Kolar gold fields may well have explained the relatively mild pneumoconiosis produced by the dust in those mines. Much controversy, however, still exists about the role of the naturally occurring substances, and it has not yet been clearly established that the supposed antidotal or delaying effects on fibrosis of these minerals is, in the long run, anything other than a dilution of the silica concentration. Moreover, despite the presence of these minerals, disabling pneumoconiosis may still result after prolonged and excessive exposure.

PART II WILL BE PUBLISHED IN THE NEXT ISSUE.

Nursing Administration

in hospital employee health services.

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For many years commercial and industrial establishments have recognized that the health of the employee is an important factor in maintaining an efficient staff to meet production or service demands. Hospitals, on the other hand, are engaged in curative and emergency care of the sick. This outlook has tended to influence hospital administrators in providing only emergency care as indicated when employees become ill. Until recently, little thought has been given to the positive approach to the health of hospital employees in an effort to maintain a competent work force. The principles of accident prevention, health maintenance and promotion that have proved effective in one work situation will, with some modification, apply to a hospital employee health program.

Limitations:

It is proposed here to discuss the nursing administration of a hospital employee health service. It is of prime importance in this instance, that the occupational health service be under the direction of a specifically designated physician. This physician should be directly responsible to the top administration of the hospital. This appointment should have continuity of tenure. Time does not permit the discussion of situations where the nursing administration does not have medical direction as stated above.

Where medical direction is not on a full time basis, the nursing administrator should have guidance on medical policies from the physician, and on employee relations from the personnel director. The nurse is also guided by other accepted nursing practices. Good team work on the part of these three experts can produce a rewarding service for hospital personnel.

Presented at the 13th International Congress on Occupational Health, New York, U.S.A., July 27th, 1960.

The Present Situation:

In reading the literature, and in visits to hospitals, it would appear that much is to be desired in hospital employee health services as compared with similar experiences in commercial and industrial employment. However, our experience is that interest and desire for an adequate health service for employees on the part of hospital administrators has increased so much in volume that we may soon find our present staff inundated with requests for assistance.

What should our consultant services offer in this area of occupational health? In Canada, the occupational health nursing consultants of government are making their services available to hospitals and are receiving an increasing number of requests for assistance in planning for facilities, personnel and services. Hospital insurance personnel are interested in means whereby greater economy plus improved services can be established in hospitals. There is no doubt that health services to employees is economical. It is timely now to present a clearly defined program acceptable to hospital administrators.

What Shall the Pattern Be?

The pattern for employee health services in industry can be applied in principle to the hospital situation. The emphasis is according to the demands of the employment as viewed by the personnel responsible for the administration of the service. The scope of occupational health services, which shall be very briefly stated, has been the basis of Canadian planning for some years now.

This has been found to be a workable pattern which we are suggesting to hospitals requesting consultation services.

Scope:

1. Health examinations or medical appraisals — preplacement, periodic, special.
2. Health education and counseling.
3. Emergency care and treatment for illness and in-

juries — occupational and non-occupational — subsequent care and treatment.

4. Participation in plant safety, sanitation, and welfare activities.
5. Co-ordination with community health and welfare agencies.
6. Administration of health services within the work situation to include general administration, record keeping and reports; interpretation of the service and trends; and participation in the public relations of the Company or Agency being served. In this case it is the hospital.

General Considerations

Service and *education*

1. Service:

(a) **For conservation of personnel**
The maintenance and promotion of the highest potential level of health of all hospital personnel is imperative for the same reasons as in industry.

(b) **As examples of healthful living**
Hospital employees are members of the health service personnel. They should be examples of good personal health practices demonstrating healthful living. To practice what we preach has always been a warning note to personnel in the health field. An employee health service will strengthen health practices.

(c) **For protection**
There should be protection of the employees from exposures to diseases brought to the hospital by patients. Conversely, the patient can be assured of protection from exposure to illnesses other than that for which he is in hospital.

(d) **Economy**
A hospital has facilities for emergency care for accidents and illnesses as a service to the public. This is not so in other employment programs. Generally speaking hospital employees have been cared for through the same services as the public, namely emergency and out-patient departments, which are treatment services. It is recommended that hospital personnel should have their health and welfare services offered through a department separate from the general public, with the emphasis on protection and promotion of health. It should be one unit where the same physician-nurse team are recognized as the administrative unit responsible for the health maintenance of the students and staff of the total hospital operation.

(e) **Extension of special skills to others.** — The employee health service can be of assistance to other departments in a hospital. Let us consider safety which is so important in industrial employment. Safety for employee and patient is of legal and moral concern to hospital administrators. The following titles of accident and safety research for patients in hospitals exemplify this concern.

Bedrails — Up or Down
The Patient's Accident Pattern
Saving Lives, Limbs and Dollars
Accidents to Patients can be Prevented
Relation of Chronic Disease and Socio-economic status to Accident Liability.

Health personnel with safety knowledge and experience in industrial health has much to contribute to the application of safety in all areas of the hospital. It should be stated as one of the objectives of hospital services.

Health maintenance and supervision through an adequate health appraisal program is essential to hospital employment legally and ethically and should be a major objective of the nation's health services.

II. Educational Programs

The occupational health personnel have an opportunity to present a learning experience in basic and post-graduate medical and nursing education; (a) through the personal health service and (b) through observation and experience by students in a health center.

There are efforts to integrate occupational health into the basic education of the student nurse with at least two emphasis; (a) in nursing care consideration to be given to the role played by the occupation of the patient and his well-being; (b) some knowledge of occupational health nursing in preparation for public health services after graduation. This educational emphasis should also be made available to medical students for the same reasons.

One of our objectives then is the integration of occupational health into basic and graduate experiences of nurses, medical students, and other allied professions.

The Program

If a nurse is requested to accept the responsibility of planning the program of an employee health service, where would she begin? Almost all hospitals with a school of nursing have an excellent health program for its student nurses. An objective of a high order these days would be to establish and maintain as efficient a health maintenance service for all other hospital personnel as there is for student nurses. This is a real challenge and is worthy of study. Dr. Felton[4] comments on this in his article, "Hospital Employees — Corridor Consultations or Health Maintenance".

Bringing together the various services to employees in one unit, the physician, nurse and personnel director will set up the program. Facts which influence the planning are six in number:

1. The purpose of the service as stated by top management.
2. The type of hospital services offered: general hospital or specific — such as by disease, by age group, by community or area, by religious group, by an industrial management (Company).
3. The history of the hospital and its original and present objectives the size of the hospital, its growth or progress to meet changing needs of those it serves; the medical and nursing progress.
4. The efficiency of the physical facilities — buildings, equipment and general work flow; the financial status.
5. The number of employees; employment policies; employee organizations which influence attitudes

towards the health service; health and welfare policies and procedures; legislation related to the service such as labor legislation and workmen's compensation.

6. A report of the general health statistics of the community served by the hospital. Attitudes of the community to hospital care, to this hospital, and towards health services.

With these general facts as background and the policies which state the purpose and scope of the program, the nurse administrator of the health service will plan the nursing service.

Physical Facilities

This is a very important factor in the success of the service. Often we have seen a well-equipped health center in industry with qualified personnel have its service defeated because of poor location. The health center must be inviting and friendly, as well as efficient, lending itself to a program separate from other hospital services. The experienced nurse will consider all factors including the work flow so there will not be any barriers to the employees use of this health center.

There are two factors which need special consideration even more than in industry. These are (1) who gives the service and (2) who has access to the records. If the student health service is brought into the unit, as we feel it should be, special consideration as to confidentiality of records must be stressed. Administrators of the service have a very vital responsibility in this respect, and especially so here, in view of student participation through observation of occupational health services. Students should not be considered as members of the staff of this service, and therefore would not have free access to the records. This is a question raised by hospital staff, particularly on the professional level.

Nursing Staff

The nurse administrator, in co-operation with the Medical Director and Personnel Director (or equivalent person of authority for employment), will consider together the number of nurses required to cover the health service. The industrial ratio of approximately one nurse to five hundred employees can be a guide. The number of employees and the ratio of professional and non-professional workers, the qualifications and experience in industrial health will be considered as factors in staffing. All hospitals should provide such a health service, regardless of size, but many hospitals with more than five hundred employees do not have a well established employee health service.

Considering that the health service to employees is one unit, a hospital with a staff of five hundred should have at least one nurse in the health service. A clerk to cover the telephone and assist in the clerical duties is valuable. When the hospital has a school of nursing, and other under-graduate and post-graduate students, there will need to be nurse members qualified to work with the school faculty to implement the requirements for integrating occupational health into the basic curriculum. This staff should also be prepared to promote health education throughout the hospital. Interpretation of good health practices and the service itself will be a challenge to the staff in an institution which is geared to the care of the sick. To many of these persons at the present time health promotion and rehabilitation is not within their usual planning and service.

Occupational health is an integral part of the total health services to the family unit. Our special service is to the adult members of the family who are gainfully employed. The business of the hospital is to give service to the sick members of the family. The health education and promotional program of the personnel in the health center can make a marked contribution to the correlation of the concepts of family health. At least one nurse in the health center should have preparation and successful experience in community or public health.

Work Flow

The number of employees who make use of the health services must be considered. A rough estimate to be expected may be stated as one visit per employee per month. If there are 500 employees, the administration can expect about 500 visits. In industry, with a five day week (20 day month) a usual figure is about 25 visits per day. We have found in some of these hospital health centers that the average of visits is not as high as in industry. This may be due partially to the accessibility of medical advice through the 'corridor consultations', and the need for persuasion to go to the health center to get advice on health needs.

Coverage of the service will need policies to include health appraisals, health education and counseling, emergency care of occupational and non-occupational accidents and illnesses. The hours of service should make the health center facilities available to all staff, but may not need coverage of a 24 hour duration.

Some Expected Outcomes:

1. An efficiently operated health service to hospital personnel should make a major contribution towards health conservation of an important group of our citizens. Special consideration should be

given to the professional group which is scarce in the employment picture. Economically and ethically there should be this conservation of qualified personnel.

If all hospital employees in a nation had adequate health supervision and guidance, there would be a marked improvement in the health index. This covers a large number of citizens in an important occupation. It would soon influence patient care, and would be a constructive example in health education to other citizens. I believe it is on its way and we in occupational health work should be ready to meet the challenge.

2. There will be a better understanding of occupational health services interpretation. Experience is the best teacher and a correlation of their student health service with other occupational health programs can be made, so that eventually these students move out into the graduate field with increased knowledge of health services for citizens at work.

The function of interpretation of occupational health to the professional staff of the hospital, if sincerely done, will enlarge the concept and importance of health maintenance for staff and patients.

3. The development of health appraisals as planned learning experiences for all hospital employees will increase the value of continuing health maintenance and will help persons to gain insight into their assets and needs to meet employment requirements through a physical and emotional inventory. Brockington[6] reminds us that work is essential to health. With this emphasis on work there is a challenge to enjoy our work.

4. It will bring to the nurse an increased awareness of the importance of occupation as related to the health of the patient. Rehabilitation of the patient is thereby enhanced by this knowledge which will follow him to his place of employment and the occupational health personnel outside hospital.

5. In all, it will increase the horizons of all health services and the value of health to each person, and will increase respect for the integrity and personal worth of all individuals. Inside and outside hospitals, health should be of prime importance rather than sickness.

6. Although this may be on the distant horizon, one must stress the need for more personnel with the public health point of view in occupational health services. Thus our services will become an integral part of the total health services of a nation. It is a service which picks up the torch when the young adult leaves the health supervision in school and goes to work.

Nursing administration in hospital employee health services is a challenge which must be planned for realistically with nurses prepared to give service, to instruct, to interpret and promote an adequate service to this valuable group of citizens —those who make hospital care possible.

References

1. Guiding principles for an occupational health program in a hospital employee group, J.A.M.A. Vol. 166, pp. 777-779 (Feb. 15) 1958. (Also in Hospitals, Vol. 32, 52, 96, 98, (Feb. 16, 1958.)
2. Guiding Principles for the Provision of Occupational Health Services, Toronto, Canadian Medical Association, 1960 (pamphlet) pp. 8.
3. Your employee health program, Ottawa, Canada, Metropolitan Life Insurance Company, 1958, pp. 24.
4. Felton, Jean S., Hospital employees — corridor consultations or health maintenance. **Journal American Medical Association,** Vol. 168, pp. 1854-1863, (Dec. 6), 1958.
5. Sloan, Harriet, J. T., An Analysis of Patient Accident Reports in a Montreal Hospital. **Medical Services Journal,** Canada. The Medical Journal of the Government of Canada, Ottawa, Vol. XV, No. 11, Dec. 1959, pp. 685-704.
6. Brockington, Fraser, M.A.M.D.: World Health, Pub. by Penguin Book Limited, 1958, pp. 404.

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